Minimizing setups and time-related objectives on multiple machines

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Abstract

Manufacturing companies use several tools on multiple machines during the production process. Tool characteristics, generalized in tool sets, prevent a particular tool from being installed on incompatible machines. However, tool generalization provides less detailed schedules. These schedules are conceived as timetables, as a result of the problems' fixed time characteristics. General and specific constraints for tools and tool sets, in combination with a makespan objective, are considered while constructing schedules. In practice these schedules are constructed manually and are thus limited to a period of up to two weeks (short term), leaving room for improvement. This work presents techniques for generating long term (multiple weeks or months) feasible solutions, focusing on multiple objectives. A late acceptance heuristic consisting of swap moves has been developed and tested on benchmark data. In addition, a prototype decision support tool has been developed and approved by practitioners.

Keywords: multiple objectives, multiple machines, changeovers, timetabling

Scheduling jobs within a manufacturing company is a weekly and/or daily process. And yet, many companies still schedule manually using different planning software. Characteristics such as economic and tool-related objectives limit manual construction of schedules and produce only short term results. The need for automated optimisation systems, that consider a significant number of problem characteristics and restrictions, increases as they provide the possibility to dynamically develop long term timetables.

Over the last years, minimizing changeovers (tool switches) and time-related objectives have received considerable attention. Restrictions between machines and tools, start and due dates of jobs as well as other time restrictions influence the scheduling complexity. Manual construction of feasible timetables with minimization of changeovers and objectives is nearly impossible. The accuracy of automated timetabling highly depends on the characteristics and restrictions considered, in combination with the efficiency of underlying algorithms.

The optimisation approach consists of a construction and an improvement phase. The constructive heuristic generates a feasible solution after which a late acceptance heuristic [1] attempts to improve the constructed solution while using swap perturbations. Delta-evaluation was implemented and provides efficient calculation of time- and tool-related objectives. Toolsets can be assigned different characteristics. Therefore, they can influence objectives: if toolset A, e.g., takes 6 hours to switch and toolset B, 1 hour, then minimizing A switches will yield the highest time profit. Furthermore, in practice, additional objectives have to be considered. A multiple objectives approach is therefore needed. A lexicographical approach provides the opportunity for users to prioritize tool- and time-related objectives. The practitioners approved the graphical decision support prototype and the model that was developed and conducted on generated benchmark data.

General economic objectives are considered within the prototype. The influence of energy cost on expenses, for example, is significant. Research concerning energy consumption deals with technical resource modifications [2], mathematical and genetic energy-aware job scheduling [3]. Additional research, where energy consumption occupies the center stage, will be conducted. This future research will aim at generalizing the aforementioned multi-objective approach for developing energy-aware optimisation system on multiple machines.

Acknowledgements: Work supported by Nervia Plastics, iMinds and the Belgian Science Policy Office (BELSPO) in the Interuniversity Attraction Pole COMEX.

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